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NAJADICOLA INGENS (KOENIKE), A WATER-MITE PARASITIC IN FRESH-WATER CLAMS

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The distribution of *Najadicola ingens* (Koenike 1895) Piersig 1897, a hydrachnid parasite of fresh-water clams in North America, is known only from a few scattered records. Relatively few specimens have been reported up to the present. Koenike (1895) described the species from specimens found in *Anodonta fragilis* Lamarck and *Unio complanata* (Solander)[1] and sent to him by Dr. Tyrrell of Ottawa. The collection locality was given only as Canada. Wolcott (1899) collected this mite from *Anodonta fragilis* at "26" Lake, near Charlevoix, Michigan, and Intermediate Lake, Ellsworth, Michigan, from *Unio gibbosus* Barnes, *U. ligamentinus* Lamarck, and *Anodonta footiana* Lea at Grand Rapids, Michigan, and from *U. luteolus* Lamarck at Long Lake, Kalamazoo, Michigan. He examined 3500 clams representing 60 species from Michigan, Wisconsin, Nebraska, New York, Illinois, Iowa, and Pennsylvania, but found not more than 16 specimens, all from the Michigan localities just mentioned. Wolcott (1918) stated that the species is generally distributed, but did not give additional distribution records. Marshall (1929) reported 16 adults and a few nymphs in two specimens of *Anodonta* in a small lake on Bruce peninsula, near Georgian Bay, Ontario. Kelly (1899) examined 1614 clams representing 44 species from Illinois, Iowa, and Pennsylvania, but reported no *N. ingens*, although he found several species of *Atax* (now *Unionicola*). In view of the abundance indicated below of *N. ingens* in New Eng-

[1]The name *Unio* is now properly applied to certain European clams, the North American species formerly included having been placed in other genera.

land, the apparent scarcity in other parts of the United States and Canada would seem to be only because of the inattention of investigators to this species and lack of collections.

During the five months from June 14 to November 19, 1949, 3077 fresh-water clams from 74 localities in New England, Quebec, and New Brunswick, representing 14 species, were examined for *N. ingens*. The mite was found in 43 or 58% of the localities. Altogether 906 specimens of *N. ingens* were collected, comprising 494 males and 412 females. Specimens of the clam hosts, together with about 50 mites of both sexes and from each of the three hosts reported below, have been deposited in the Museum of Comparative Zoology, Harvard University. The assistance of Mr. William J. Clench of the Museum of Comparative Zoology in identifying the clams is gratefully acknowledged.

Mites were collected from clams in the following localities which are indicated on the accompanying map (Fig. 1):

Massachusetts: (1)Sampson Pond, South Carver; (2)Monponsett Pond, Halifax; (3)Unionville Pond, Holden; (4)Carbuncle Pond, Oxford; (5)Lake Chaubunagungamaug, Webster; (6) Wickaboag Pond, West Brookfield; (7)Sandy Pond, Ayer; (8) Ward Pond, Ashby; (9)Nabnassett Pond, Tyngsboro; (10) Mashpee Pond, Mashpee; (11)Buckmaster Pond, Westwood; (12)Lake Winneconnet, Taunton; (13)Quarter Mile Pond, Medford; (14)Forge Pond, Westford; (15)Bare Hill Pond, Harvard; (16)Warner's Pond, Concord; (17)Heart Pond, South Chelmsford; (18)Lake Cochichewick, North Andover; (19)Winter Pond, Winchester; (20)Lake Attitash, Amesbury; (21)Fort Pond, Lancaster; (22)Hoosicwhisick Pond, Milton; (23)Hemenway Pond, Milton.

Rhode Island: (24)Worden's Pond, South Kingston.

Vermont: (25)Island Pond, Brighton; (26)Bomoseen Lake, Castleton; (27)Lake Champlain at Sandbar State Forest Park, Milton.

New Hampshire: (28)Crystal Lake, Eaton Center; (29)Province Lake, Effingham; (30)Wash Pond, Hampstead; (31)Island Pond, Hampstead; (32)Great Pond, Kingston; (33)Angle Pond, East Hampstead; (34)Country Pond, Newton.

Maine: (35)Long Pond, at Long Pond; (36)Madawaska Lake, Stockholm; (37)stream at Ouelette; (38)Eagle Lake; (39)

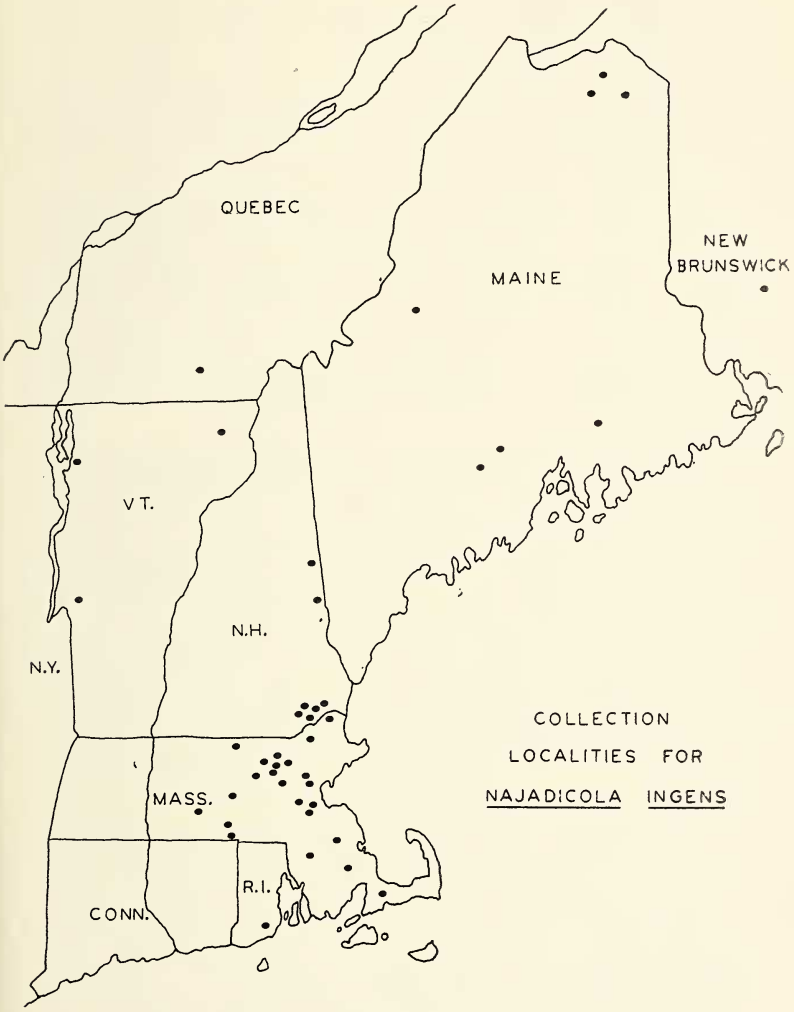


Fig. 1. Localities in New England, Quebec, and New Brunswick where *Najadicola ingens* was collected.

Park's Pond, Clifton; (40)Unity Pond, Unity; (41)China Lake, China.

Quebec: (42)Massawippi Lake, at Ayer's Cliff.

New Brunswick: (43)Cranberry Lake, Harvey Station.

Of the 14 species of clam hosts 3 were parasitized by *N. ingens* and 11 were negative. The 3 positive species were *Elliptio complanatus* (Solander) (2054 specimens of which 231 or 11.2% were positive), *Anodonta cataracta* Say (625 specimens of which 242 or 38.7% were positive), and *Lampsilis radiata* (Gmelin) (152 specimens of which 18 or 11.8% were positive). The negative species included 17 *Ligumia nasuta* (Say), 3 *Lampsilis cariosa* (Say), 3 *Lampsilis ventricosa* (Barnes), 19 *Lampsilis ochracea* (Say), 79 *Anodonta implicata* Say, 59 *Anodonta marginata* Say, 38 *Alasmidonta undulata* (Say), 1 *Alasmidonta heterodon* (Lea), 25 *Strophitus rugosus* Swainson, 1 *Leptodea fragilis* Rafinesque, and 1 *Proptera alata* Say.

The highest degree of parasitism in any single locality was 87.3% for *Anodonta cataracta* at Wash Pond, N.H., and 57% for *Elliptio complanatus* at Crystal Lake, N.H.

Judging from the relative number of individual clams parasitized, the preferred host seems to be *Anodonta cataracta,* with 1 out of every 3 clams containing mites. *Elliptio complanatus* appears to be next in preference, with 1 out of every 9 parasitized. *Lampsilis radiata* seems least preferred of the three hosts. The high figure of 11.8% is misleading, since it is based upon parasitized clams from only two localities. One, Massawippi Lake, Quebec, produced 18 clams of which 16 were parasitized; the other, Lake Champlain at Sandbar State Forest Park, Vt., comprised 23 *L. radiata* of which only 2 contained mites. The remaining 134 *L. radiata* were negative.

The samples of clams from the various localities were not of equal size. At several localities only a few clams were collected. Table I shows the number of clams of each of the 3 host species examined in the 43 localities. The numbers in parentheses indicate the number of individuals which were parasitized by *N. ingens.* The average number of clams examined of all 14 species in the 43 positive localities was 51 (1-253) and in the 31 negative localities 28 (3-134). Only 2 of the negative localities comprised more than 100 clams. Excluding these the average number of clams examined in 29 negative localities becomes 21 (3-80). These data indicate the possibil-

locality number	*Anodonta cataracta*	*Elliptio complanatus*	*Lampsilis radiata*	locality number	*Anodonta cataracta*	*Elliptio complanatus*	*Lampsilis radiata*
1		16(1)	3	23	75(27)	7	1
2	4	16(1)		24		64(6)	1
3	2(2)	4		25	6(6)	16	
4	1(1)			26	10(2)	4	4
5	8	113(12)		27		18(2)	23(1)
6	29(9)			28	9	63(36)	
7		54(7)		29		25(12)	
8		15(2)		30	142(124)		
9	25(1)	208(43)	20	31	23(21)	22(2)	
10	2	16(1)	3	32	4(1)	12(3)	
11	8(5)	32		33	2(1)	6	
12		77(8)	19	34	2	5(2)	
13	4(4)			35	13	12(1)	
14	2	80(3)	1	36	12(3)	11	
15	2(2)	18		37	3(1)	9	
16		185(7)	1	38	11(1)	11	
17	26(2)	5	2	39	22	10(1)	
18	2(2)			40	17	17(1)	12
19	1(1)			41		34(2)	1
20	19	57(19)	8	42	11	22	18(16)
21	11(8)	193(49)		43	4(4)	12	2
22		46(6)	1				

Table I. The total number of clams examined and number with *N. ingens* for each of the three host species in the 43 positive localities.

ity that mites in certain localities may have been overlooked because of the small sampling.

Commonly 1 male and 1 female mite were found in each parasitized *A. cataracta* and *E. complanatus*. Single males and single females were frequently found in these clams, but very rarely two of the same sex. This was not the case in *L. radiata*, where at least two of each sex were present, one clam having 4 males and 8 females. The average number of mites per clam was 1.7 in *E. complanatus* and 1.8 in *A. cataracta*.

The smaller and presumably younger individuals of *E. complanatus* and *A. cataracta* were more frequently parasitized, as shown in Figs. 2 and 3. The arithmetical mean length for unparasitized *E. complanatus* was 6.9 cm. and for parasitized individuals 5.6 cm. The arithmetical mean length for unparasitized *A. cataracta* was 7.1 cm. and for parasitized individuals 6.2 cm. The largest parasitized clam was an *A. cataracta* 11.2 cm. in length. The smallest was an *E. complanatus* 2.7 cm. in length.

The position of *N. ingens* in the host clams varied with the host species. Almost invariably when there was a male and a female present they occurred in the same suprabranchial chamber, usually in the anterior half of the gill area. Immature mites or single males were generally located distally between the gill lamellae. The mites occurred in any of the four suprabranchial chambers, but there was noticed a distinct difference in location in *E. complanatus* and *A. cataracta*. In *A. cataracta* the mites occurred with about equal frequency in the right and left outer suprabranchial chambers. In only 4 individuals were mites found in the inner gill chambers. In *E. complanatus* the mites occurred nearly equally in the right and left inner suprabranchial chambers. In only 6 individuals were mites found in the outer gill chambers. Since mites were found in the outer chambers of *E. complanatus* and in the inner chambers of *A. cataracta*, they are probably not mechanically prevented from entering those chambers. The position of the mites seems to have little relation to the use of the gill as a marsupium, since in *A. cataracta* mites were found in both gravid and non-gravid gills. According to Baker (1928) the specialized long-term breeding clams like *Anodonta* have the gills modified to provide better water circulation than in the short-term breeders like *Elliptio*. This may have some bearing on the difference in location of the mites in the two clam genera. It is of interest to note that both these genera use the

two outer gills as marsupia. In the 17 positive *Lampsilis radiata* the mites occurred nearly equally in the four suprabranchial chambers. One clam had mites in all four of its suprabranchial chambers.

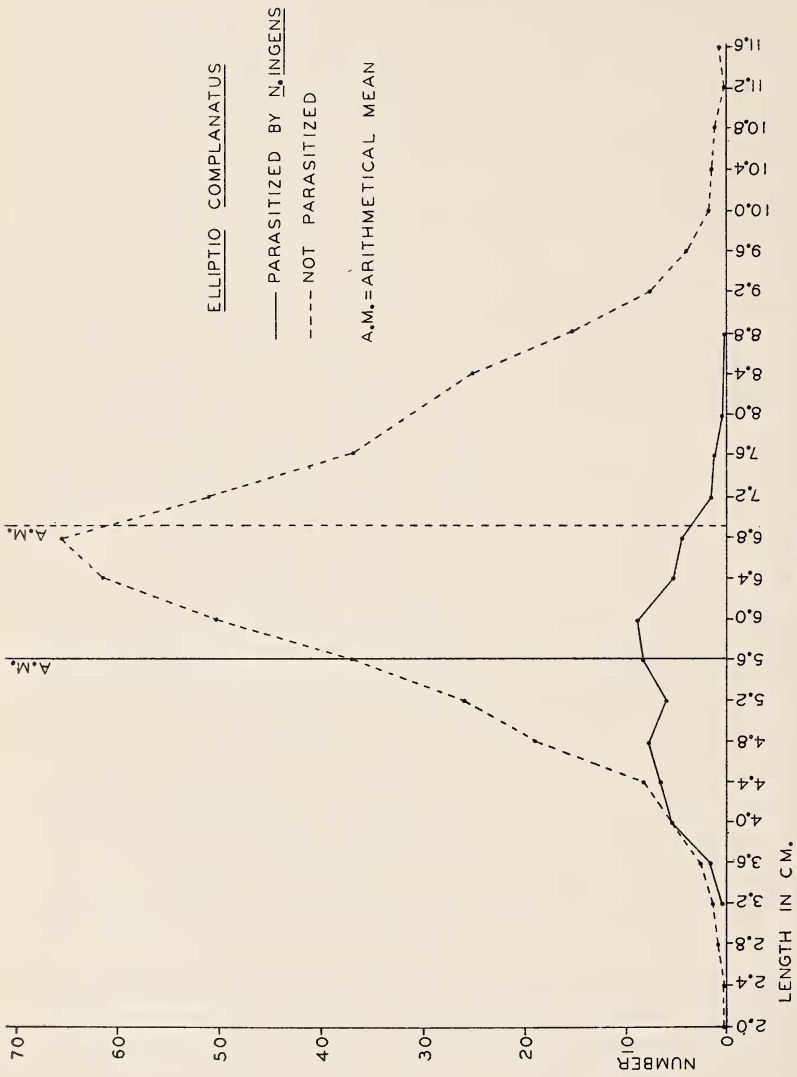
Ninety-one per cent of the parasitized clams had papillae of various sizes on the walls of the suprabranchial chambers. As many as 40 papillae were counted in one suprabranchial chamber containing a pair of mites. The largest papillae measured were 3 mm. in diameter and 5 mm. in length. Fig. 4 shows a specimen of *Anodonta cataracta* from which the left valve and mantle have been removed. The left outer suprabranchial chamber has been opened to show the papillae, a male and a female *N. ingens,* and several small, dark egg masses. In only 10 clams were papillae found without mites. Presumably these clams had previously been parasitized by *N. ingens.* The papillae were often arranged in an incomplete ring around the mites and their egg masses, perhaps acting as a barrier to prevent the eggs from being carried out of the gill chambers, either via the excurrent siphon in *Anodonta* or into the mantle cavity by way of the incomplete connection of the innermost gill lamella and visceral mass in *Elliptio.* The papillae occur mostly within the suprabranchial chambers, but in a few cases in *E. complanatus* extended down on the side of the visceral mass.

The presence of the mites apparently interferes with the use of the gills as marsupia. In many gravid, parasitized *A. cataracta* the marsupia containing mites were asymmetrically developed. The anterior half of the parasitized gill contained few or no glochidia, while the unparasitized gill of the opposite side was normally developed.

The factors involved in regulating the geographical distribution of *N. ingens* are difficult to determine. The mites occurred in small ponds, large lakes, and in slowly flowing streams. All clams examined were taken from a depth of not more than 4 feet. The types of bottom included soft clay, silt, fine white sand, gravel, or small stones.

Both *N. ingens* and species of *Unionicola* were occasionally found in the same clam host. Adults of the two genera are easily differentiated, *Najadicola* being larger, cream-colored, and remaining within the suprabranchial chambers, while *Unionicola* is smaller, dark-colored, and crawling about over the surface of the gills and mantle.

The eggs of *N. ingens* are laid in masses in the suprabranchial


ELLIPTIO COMPLANATUS
PARASITIZED BY N. INGENS
NOT PARASITIZED
A.M.=ARITHMETICAL MEAN
A.M.
A.M.
NUMBER
LENGTH IN CM.
0
10
20
30
40
50
60
70
2.0
2.4
2.8
3.2
3.6
4.0
4.4
4.8
5.2
5.6
6.0
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10.4
10.8
11.2
11.6

Figure 2

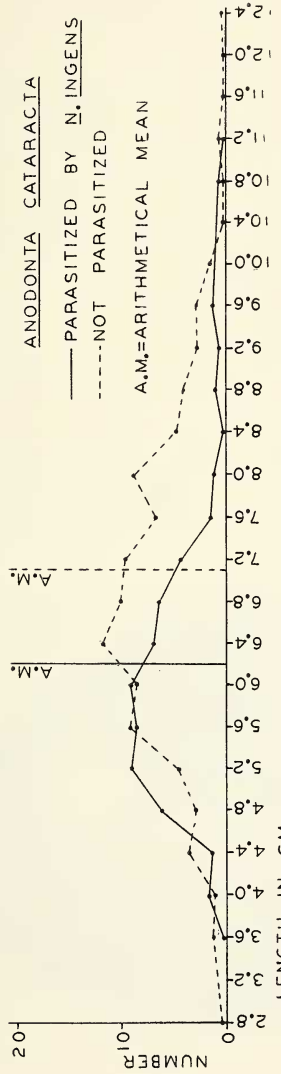

Figure 3

Fig. 2. Size of *Elliptio complanatus* indicated by length of shell valve in relation to presence of *Najadicola ingens*.

Fig. 3. Size of *Anodonta cataracta* indicated by length of shell valve in relation to presence of *Najadicola ingens*.

chambers of the clams, not inserted into the mantle or gills as in *Unionicola*. The greatest number of egg masses found in a single clam was 23 in one *A. cataracta*. Each egg mass contained approximately 250-300 eggs, and was enclosed in gelatinous material, lying unattached in the suprabranchial chamber. The color of the eggs varied from light cream when freshly laid, through orange, to nearly black when about to hatch. Masses of light cream-colored eggs were hatched in 17 days in distilled water at summer room temperature.

Sexual dimorphism is very pronounced in *N. ingens*, gravid females reaching a diameter of 5 x 6 mm., 3 or 4 times that of males. The color varies from honey yellow to light reddish brown. Microscopically the sexes may be recognized by the position of the pair of triangular genital plates. Those of the male are contiguous medially, while in the female the two plates are separated. The average number of acetabula per plate in 10 males was 72 (39-142) and in 10 females 94 (59-122). The two acetabula located near the outer apex of the plate are larger than the others.

Adult *N. ingens* can survive for several weeks at least outside the clam host. In distilled water at summer room temperature a male survived 36 days and a female 49 days. The female laid eggs during this period.

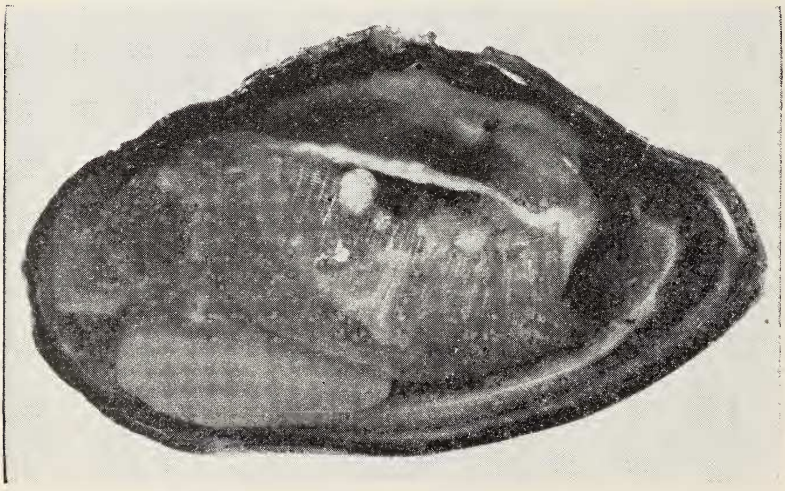

Fig. 4. *Anodonta cataracta* with left valve and mantle removed and left outer suprabranchial chamber opened to show papillae, a male and a female *N. ingens*, and several small, dark egg masses. (x1.5)

Summary

Najadicola ingens is reported from 43 localities in Massachusetts, Rhode Island, Vermont, New Hampshire, Maine, Quebec, and New Brunswick, after an examination of 3077 fresh-water clams from 74 localities in New England and adjacent areas of Canada. The mite parasitizes principally two host clams, *Anodonta cataracta* and *Elliptio complanatus,* and occasionally *Lampsilis radiata.*

The smaller and presumably younger *A. cataracta* and *E. complanatus* are parasitized more often than larger individuals. In *A. cataracta* the mites occur mostly in the outer suprabranchial chambers, but in *E. complanatus* in the inner suprabranchial chambers. The walls of the suprabranchial chambers containing mites almost invariably bear numerous papillae. The presence of mites in gravid gills apparently interferes with the normal use of the gill as a marsupium.

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